CAN WE *SUCCESSFULLY* MANAGE WEEDS ON A LANDSCAPE SCALE WITHOUT HERBICIDES?

Lessons Learned 10 Years into Zero-Use

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Marin Municipal Water District

A little background

- MMWD provides drinking water to 180,000 people in southern Marin.
- Water comes from the Mt Tamalpais Watershed, an 18,000 acre biodiversity hotspot.
- We have approximately 1,400 acres of broom.

Mission Statement: To manage our natural resources in a sustainable manner, and to provide our customers with reliable, high-quality water at a reasonable price.

Weed control is central to our fuelbreak maintenance work

Weed control is central to our biodiversity protection work

Herbicide prohibition 2005 to present

District policy prohibits the use of ***ALL*** herbicides in the Mt Tamalpais Watershed.

The prohibition was established in response to public concern and extended due to regulatory uncertainty.

Primary tools now in the toolbox

Mowing

Manual weeding

Secondary tools

Conventional mulch

Sheet mulch

Solarization

Prescribed burning

Volunteer work parties

Systematic review of alternatives: 2003 to present

Terra Torch

Organic Herbicides
Citric Acid
Vinegar
Clove oil extract
D-limonene
Pelargonic acid

Mechanical Alternatives
Pressurized water (HMO)
Other mower heads
Sub-soil brushing
Girdling
Bark peel
Weed Wrench alternatives

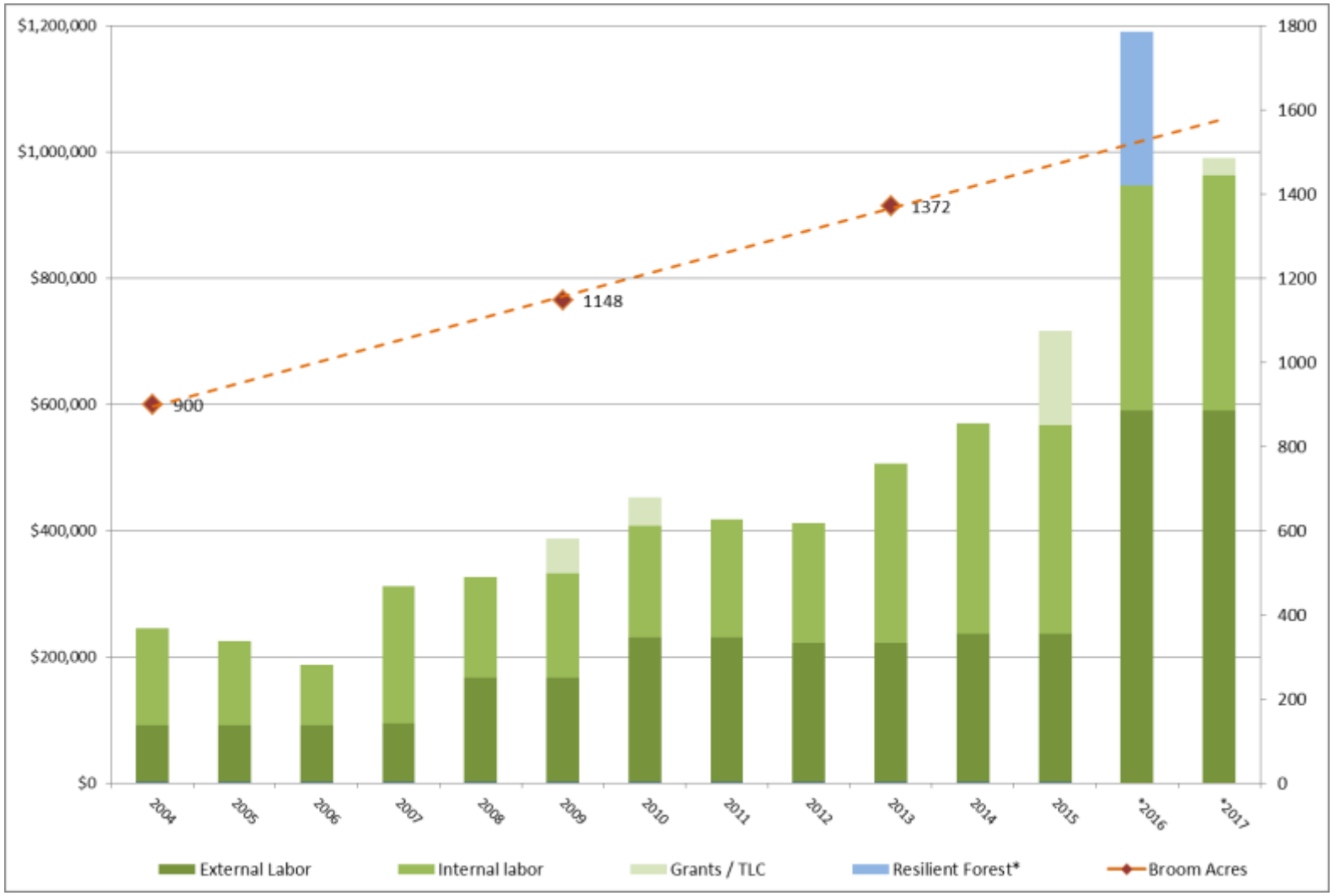
Biological Control Agents
Rusts
Smuts
Psyllids
Weevils
Beetles
Nematodes
Genista moths
Scotch broom gall mites

Hot foam

Grazing

Propane flaming

Spending is increasing, but broom has a head start



- One time reallocation of internal crews for Carbon / Water Yield Study plot installation

Upshot: We need better tools and we need to take a landscape-scale approach to the work

~~**Terra Torch:**~~ fun but dangerous

Grazing: suitable sites limited, trials in 2003, 2014 and 2015 not encouraging

Organic Herbicides

~~Citric Acid~~
~~Vinegar~~
~~Clove oil extract:~~
~~D-limonene~~
~~Pelargonic acid:~~

Mechanical Alternatives

~~Pressurized water (HMO)~~
Other mower heads: YES!
~~Sub-soil brushing~~
Girdling: occasionally
~~Bark peel~~
Weed Wrench alternatives: Still looking

Biological Control Agents

~~Rusts~~ present but ineffective
~~Smuts~~ present but ineffective
~~Psyllids~~
~~Weevils~~
~~Beetles~~
~~Nematodes~~
Mites / Caterpillars present / but ineffective

~~**Hot foam:**~~ Company failed, toxicity concerns with foaming agent

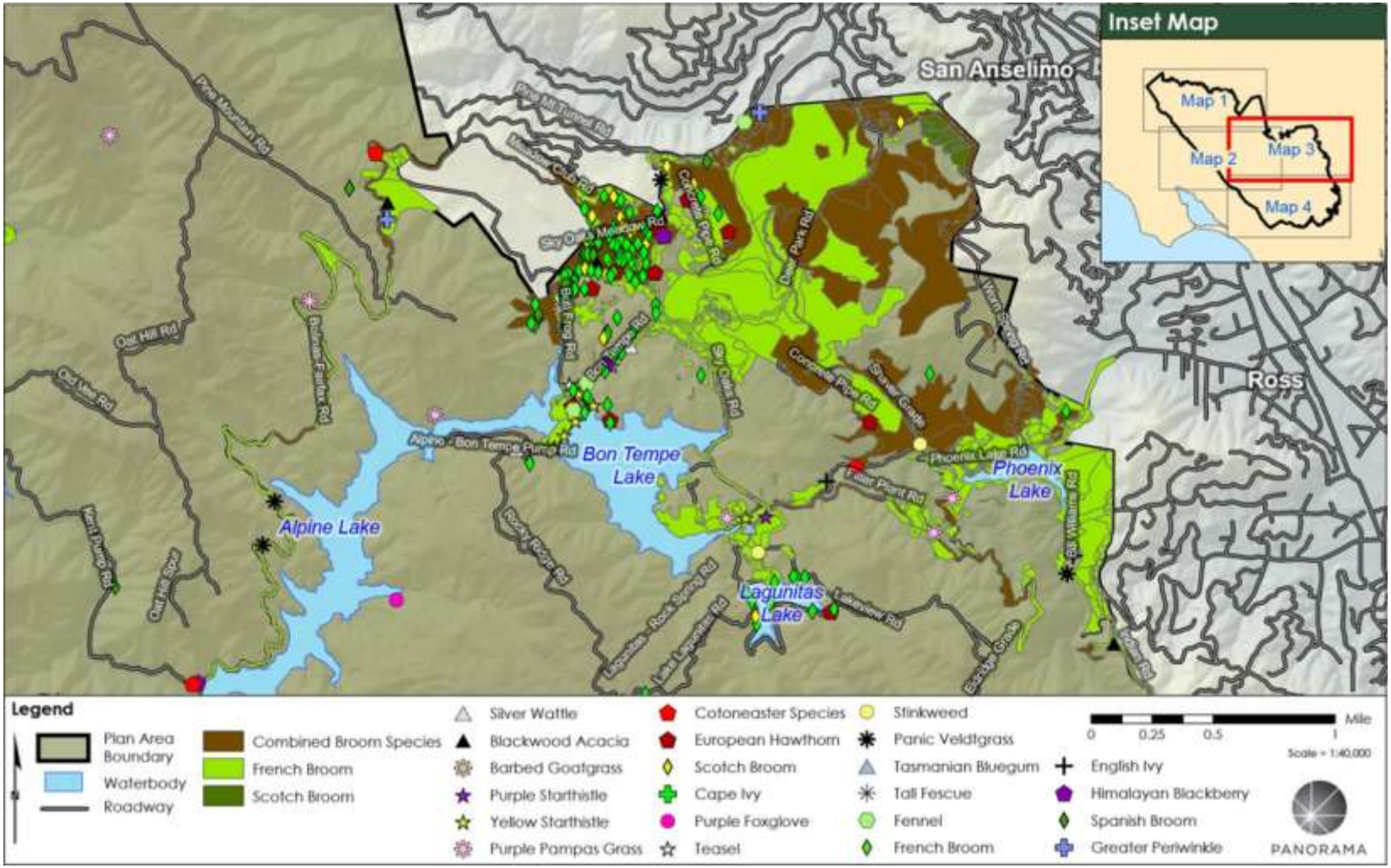
Propane flaming: suitable sites limited Not as efficient as alternatives

Stepping back to re-assess

- **Understanding the full situation**
- **Good goals**
- **Meaningful metrics**
- **Realistic expectations**
- **Raised resources**

Good maps

MMWD invests $20-50,000 every 3 years to update weed and other vegetation maps



There's more to weeds than broom

Stepped-up early detection surveys and botanical blitzes added 102 plants to the 900+ on our list.

59 of those were not native, including

- **THOROUGHWORT, *AGERATINA ADENOPHORA***
- African asparagus fern, *Asparagus asparagoides*
- **HANGING SEDGE, *CAREX PENDULA***
- New Zealand cabbage tree, *Cordyline australis*
- **MILKFLOWER COTONEASTER, *COTONEASTER LACTEUS***
- **PORTUGUESE BROOM, *CYTISUS STRIATUS***
- **OBLONG SPURGE, *EUPHORBIA OBLONGATA***
- Herb Robert, *Geranium purpureum*
- Yellow flag iris, *Iris pseudacorus*
- Peavines, *Lathyrus sphaericus* and *tingitanus*
- Glossy privet, *Ligustrum lucidum*
- Mini-marguerite, *Mauranthemum paludosum*
- White sweetclover, *Melilotus albus*
- Woodsorrels, *Oxalis latifolia* and *rubra*
- Dyer's mignonette, *Reseda luteola*

There's more to weeds than broom

New weeds, continued

- **ROSY SAND CROCUS, *ROMULEA ROSEA* VAR. *AUSTRALIS***
- Purple awned wallaby grass, *Rytidosperma penicillatum*
- **INDIAN HEDGE MUSTARD, *SISYMBRIUM ORIENTALE***
- **HARLEQUIN FLOWER, *SPARAXIS TRICOLOR***
- **SMILO GRASS, *STIPA MILIACEA* VAR. *MILIACEA***
- Narrow leaved clover, *Trifolium angustifolium*
- Hop clover, *Trifolium campestre*
- White clover, *Trifolium repens*
- Woolly clover, *Trifolium tomentosum*

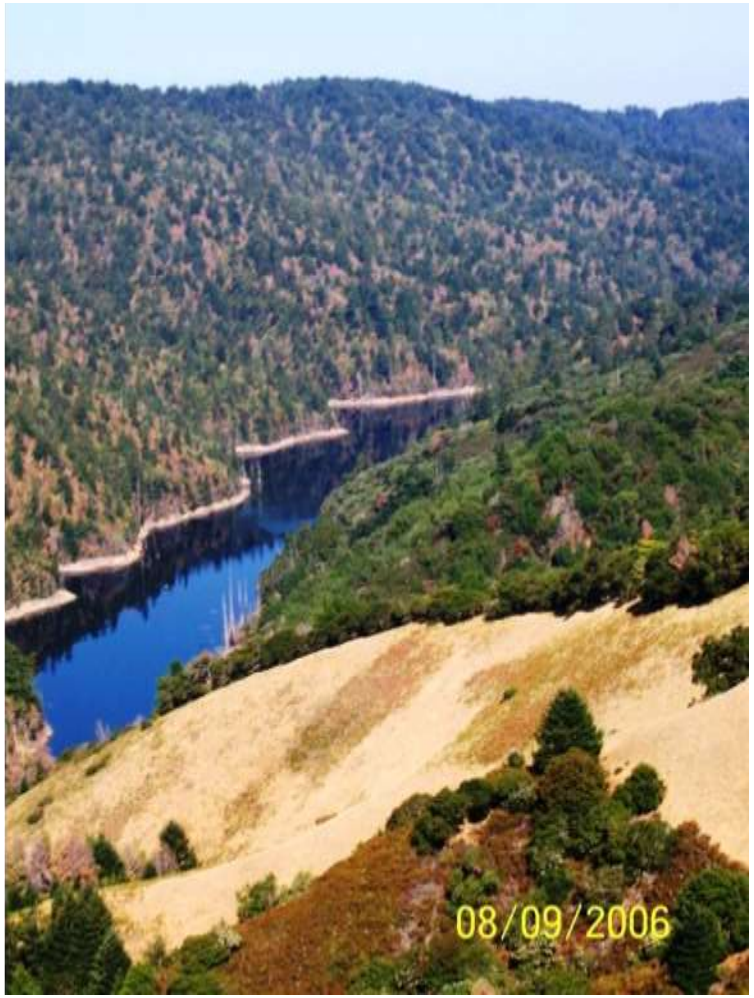
Plus new populations of EDRR targets

- Barbed goatgrass, *Aegilops triuncialis*
- Stinkwort, *Dittrichia graveolens*
- Panic veldtgrass, *Ehrharta erecta*
- Medusahead, *Elymus caput-medusae*

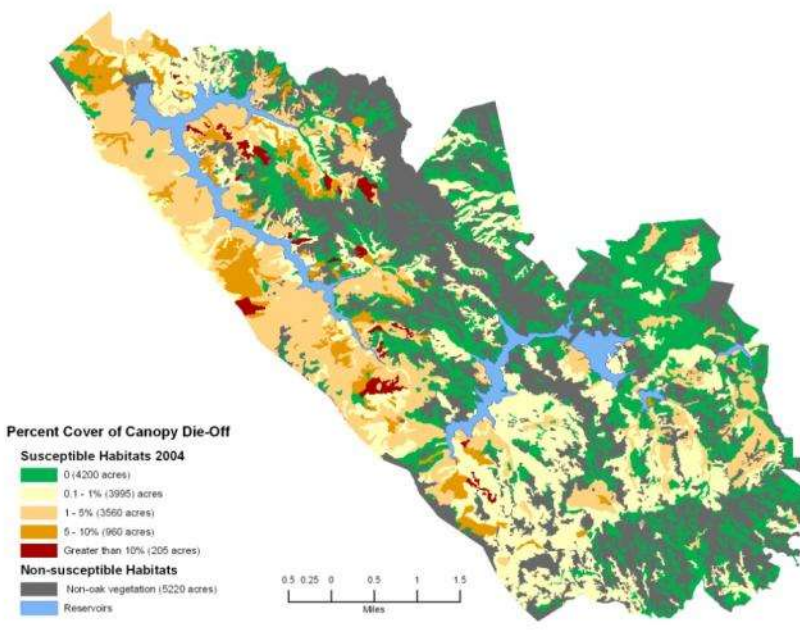
Only NINE of the new weeds are currently in a control program. Six more are being considered for control.

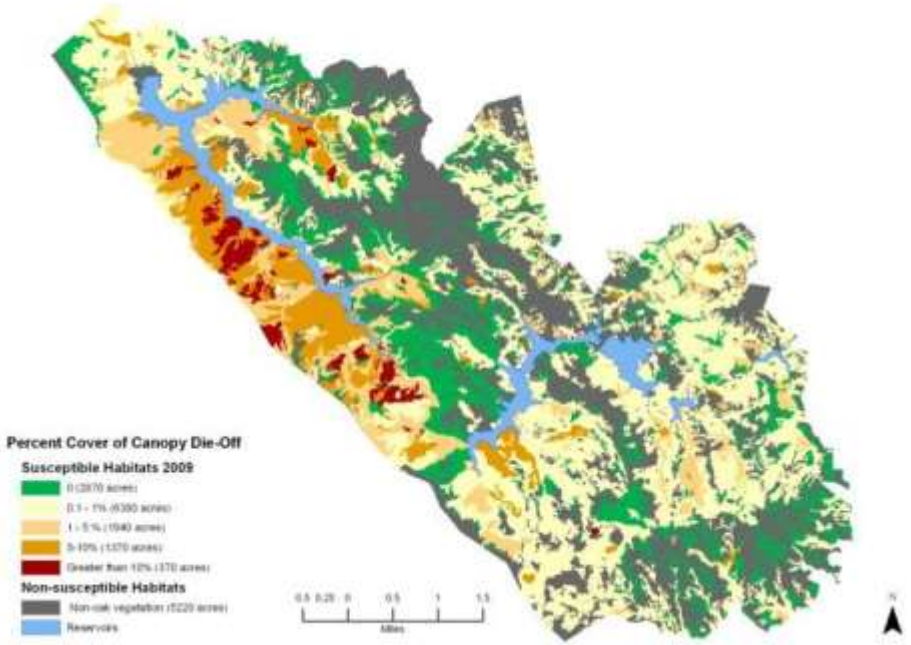
There's more to the mountain than weeds

Bolinas Ridge 2006



SOD impacts are also expanding





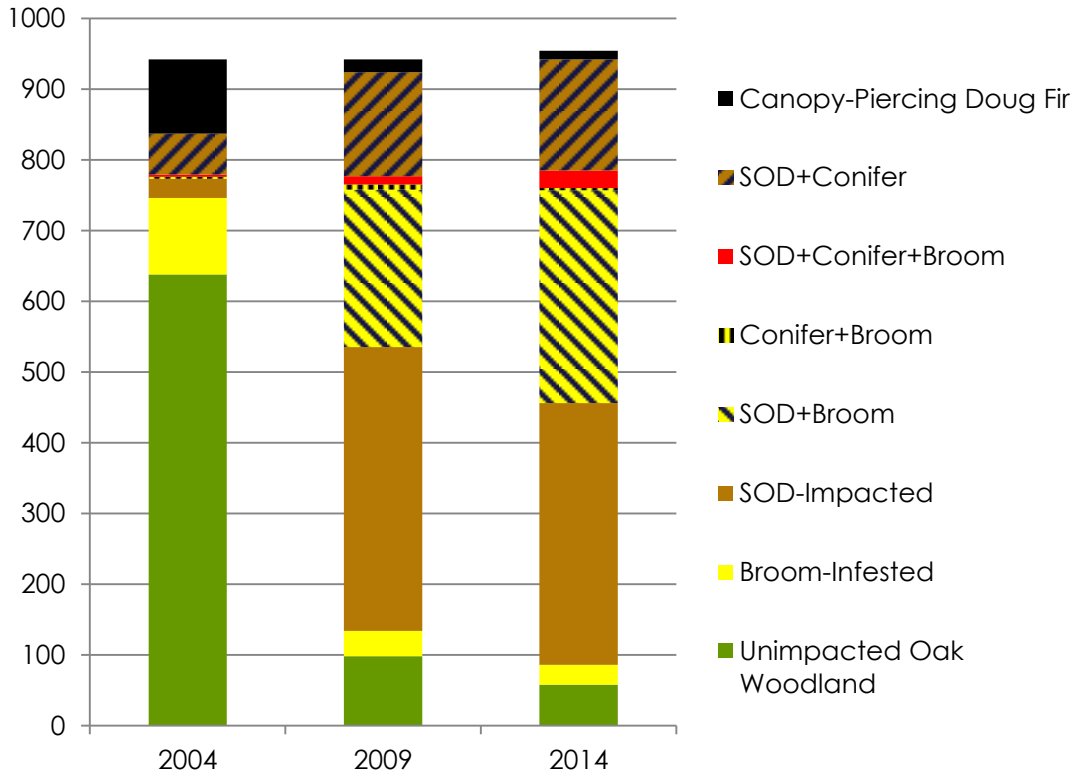
Over 10,000 acres impacted to date

…Which means the work plan has to factor in tasks and projects other than weeds.

Compounding stressors

SOD isn't just the loss of tanoak

Oak woodlands—mostly coast live oak—are being impacted by SOD, broom, and conifer encroachment



There's more to monitor than weeds

Mt Tamalpais has lost 5-10% of its native plants in the last 50 years—and no one noticed

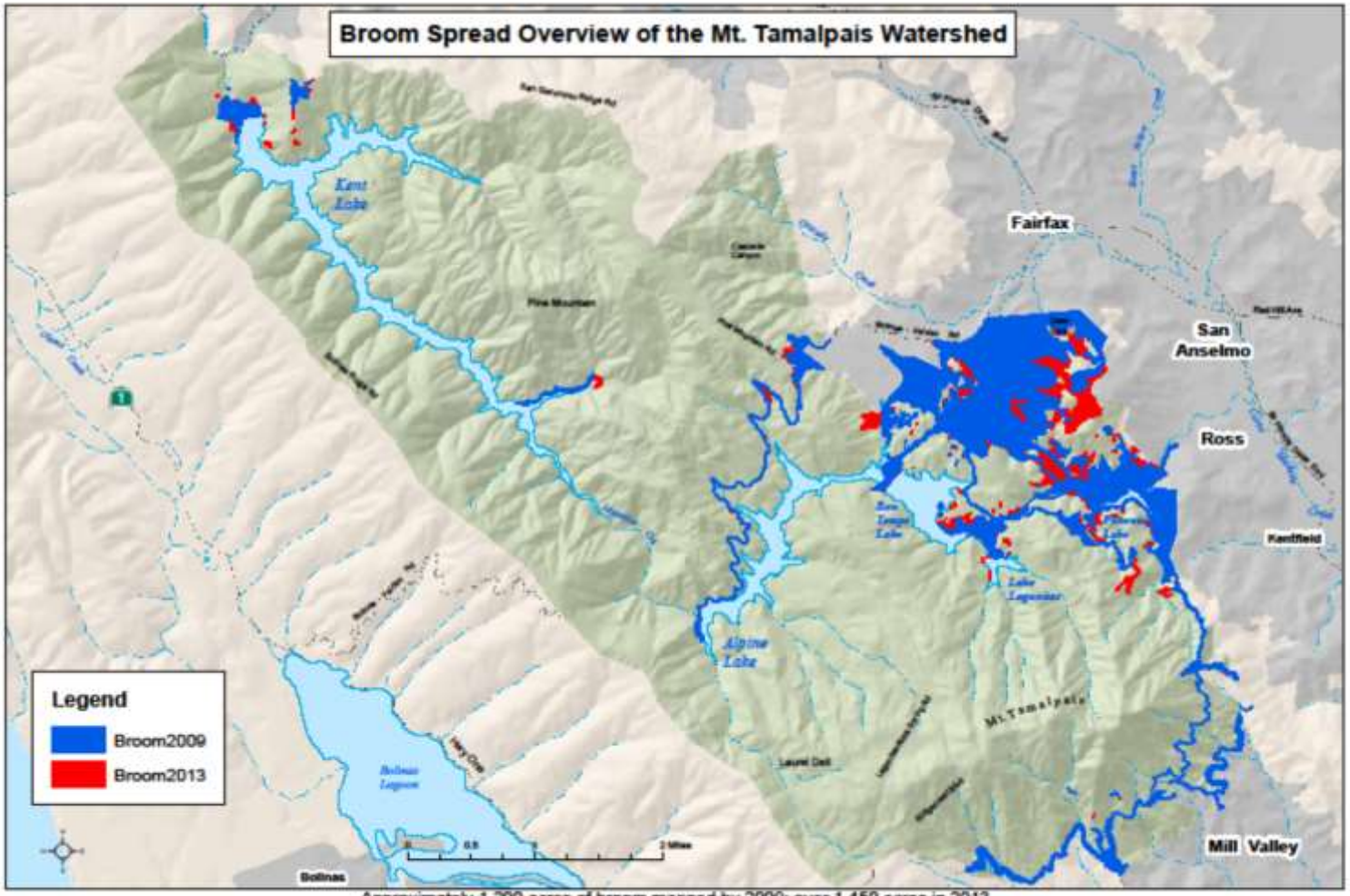
Formal metrics: Annual Work Plan/ Performance Criteria

Marin Municipal Water District

Action	Performance Criteria	Unit	2016
Cyclical Fuelbreak Maintenance	Retreat fuels in existing fuelbreaks	acres	195
	Cyclical mowing of fine fuels	acres	10
	Cyclical removal of broom in Optimized and Transitional Zones	acres	200
Fuelbreak Construction	New fuelbreak construction	acres	0
Early Detection Rapid Response	Annual surveys	miles	150
	Weed control treatments	patches	20
Forest Stand Structure improvement	Reduce accumulated fuels and brush	acres	33
	Prescribed burning	acres	0
Grassland and Oakwoodland improvement	Douglas Fir thinning	acres	30
	Prescribed burning	acres	0
	Broom: Initial removal	acres	10
	Broom: Long term maintenance	acres	275
	Yellow Star thistle	acres	80
	Goat grass	acres	32
	Other weeds	ıto MA-25, MA 24, or MA 22	
Reintroduce species	Planting	acres	0.1
	habitat modification	patches	0.1
Meadow Restoration	Implementation	acres	
Weed Control trials	Implementation	project	1

Maps as metrics

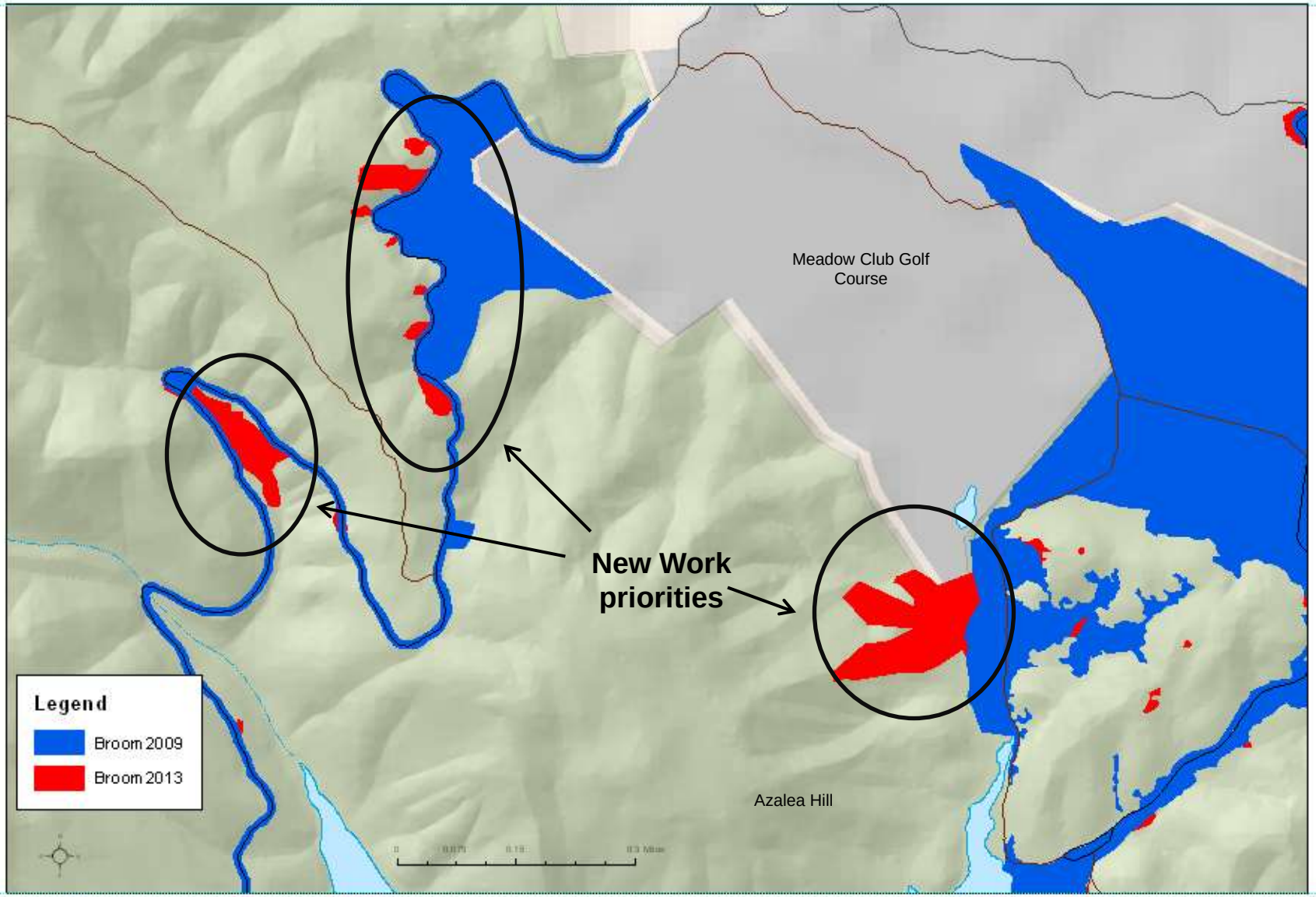
Time series maps are essential for measuring effectiveness



Approximately 1,200 acres of broom mapped by 2009; over 1,450 acres in 2013

While we may contain 20 acres in one area, another 60 pop up elsewhere

Where have we failed to contain weeds and where should we go next?



Other metrics
Effort—also known as person hours or cost

2016	MMWD	A MMWD Staff	3/26/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		6	$ 17.01	$ 17.01	$ 102.06
2016	MMWD	A MMWD Staff	3/26/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		8	$ 25.52	$ 25.52	$ 204.12
2016	MMWD	A MMWD Staff	3/26/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		8	$ 29.45	$ 29.45	$ 235.56
2016	MMWD	A MMWD Staff	3/26/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		8	$ 43.01	$ 57.20	$ 457.62
2016	MMWD	A MMWD Staff	3/26/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		7.5	$ 74.71	$ 99.36	$ 745.22
2016	MMWD	A MMWD Staff	3/28/2016	807682	MT-NR-VMU	Vegetation Management Units	Misc. Tree Removal FY 2013/14	0050	Misc. Tree Removal FY 2013/14	2	$ 38.69	$ 51.46	$ 102.91
2016	MMWD	A MMWD Staff	3/28/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		1	$ 17.01	$ 17.01	$ 17.01
2016	MMWD	A MMWD Staff	3/28/2016	807860	MT-NR	Watershed	Vegetation monitoring FY14	0160		1	$ 17.01	$ 17.01	$ 17.01
2016	MMWD	A MMWD Staff	3/28/2016	807860	MT-NR	Watershed	Vegetation monitoring FY14	0160		1	$ 19.63	$ 19.63	$ 19.63
2016	MMWD	A MMWD Staff	3/28/2016	809261	MT-NR-VMU	Vegetation Management Units	Pine Point; habitat and fuel reduction w	0060	Pile burning	8	$ 38.69	$ 51.46	$ 411.65
2016	MMWD	A MMWD Staff	3/28/2016	809261	MT-NR-VMU	Vegetation Management Units	Pine Point; habitat and fuel reduction w	0060	Pile burning	6	$ 38.69	$ 51.46	$ 308.73
2016	MMWD	A MMWD Staff	3/28/2016	809261	MT-NR-VMU	Vegetation Management Units	Pine Point; habitat and fuel reduction w	0060	Pile burning	8	$ 41.03	$ 54.56	$ 436.51
2016	MMWD	A MMWD Staff	3/28/2016	809261	MT-NR-VMU	Vegetation Management Units	Pine Point; habitat and fuel reduction w	0120	Monitoring/Assessment (during/post-work)	1	$ 54.68	$ 72.72	$ 72.72
2016	MMWD	A MMWD Staff	3/28/2016	809306	MT-NR-VMU	Vegetation Management Units	Resilient Forest Project	0120	Monitoring/Assessment (during/post-work)	6	$ 17.01	$ 17.01	$ 102.06
2016	MMWD	A MMWD Staff	3/28/2016	809306	MT-NR-VMU	Vegetation Management Units	Resilient Forest Project	0120	Monitoring/Assessment (during/post-work)	6	$ 19.63	$ 19.63	$ 117.78
2016	MMWD	A MMWD Staff	3/28/2016	809760	MT-RT-RDS-ELDGRARX	Eldridge Grade	Upper Eldridge Grade road brushing	0030	Heavy equipment brushing/mowing	8	$ 19.63	$ 19.63	$ 157.04
2016	MMWD	A MMWD Staff	3/28/2016	809760	MT-RT-RDS-ELDGRARX	Eldridge Grade	Upper Eldridge Grade road brushing	0030	Heavy equipment brushing/mowing	8	$ 38.69	$ 51.46	$ 411.65
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2016	MMWD	A MMWD Staff	3/29/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		2	$ 17.01	$ 17.01	$ 34.02
2016	MMWD	A MMWD Staff	3/29/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		2	$ 19.63	$ 19.63	$ 39.26
2016	MMWD	A MMWD Staff	3/29/2016	808904	MT-NR-VMU	Vegetation Management Units	EDRR 2015 Watershed-wide	0070	Weed killing (hand tool/pull/dig/flame)	6	$ 19.63	$ 19.63	$ 117.78
2016	MMWD	A MMWD Staff	3/29/2016	809261	MT-NR-VMU	Vegetation Management Units	Pine Point; habitat and fuel reduction w	0060	Pile burning	6	$ 38.69	$ 51.46	$ 308.73
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2016	MMWD	A MMWD Staff	3/30/2016	807840	MT-NR	Watershed	Bioblitz 2014	0160		1	$ 17.01	$ 17.01	$ 17.01
2016	MMWD	A MMWD Staff	3/30/2016	808904	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/30/2016	808904	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	807840	MT-NR								
2016	MMWD	A MMWD Staff	3/31/2016	808904	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	808904	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	808904	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	808904	MT-NR-VMU								
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2016	MMWD	A MMWD Staff	3/31/2016	809261	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	809261	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	809261	MT-NR-VMU								
2016	MMWD	A MMWD Staff	3/31/2016	809760	MT-RT-RDS-ELDGRARX								
2016	MMWD	A MMWD Staff	3/31/2016	809760	MT-RT-RDS-ELDGRARX								
2016	MMWD	A MMWD Staff	3/31/2016	809760	MT-RT-RDS-ELDGRARX								
2016	MMWD	A MMWD Staff	4/1/2016	807840	MT-NR								
2016	MMWD	A MMWD Staff	4/1/2016	807840	MT-NR								
2016	MMWD	A MMWD Staff	4/1/2016	807840	MT-NR								
2016	MMWD	A MMWD Staff	4/1/2016	808185	MT-NR								
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2016	MMWD	A MMWD Staff	4/1/2016	809760	MT-RT-RDS-ELDGRARX								
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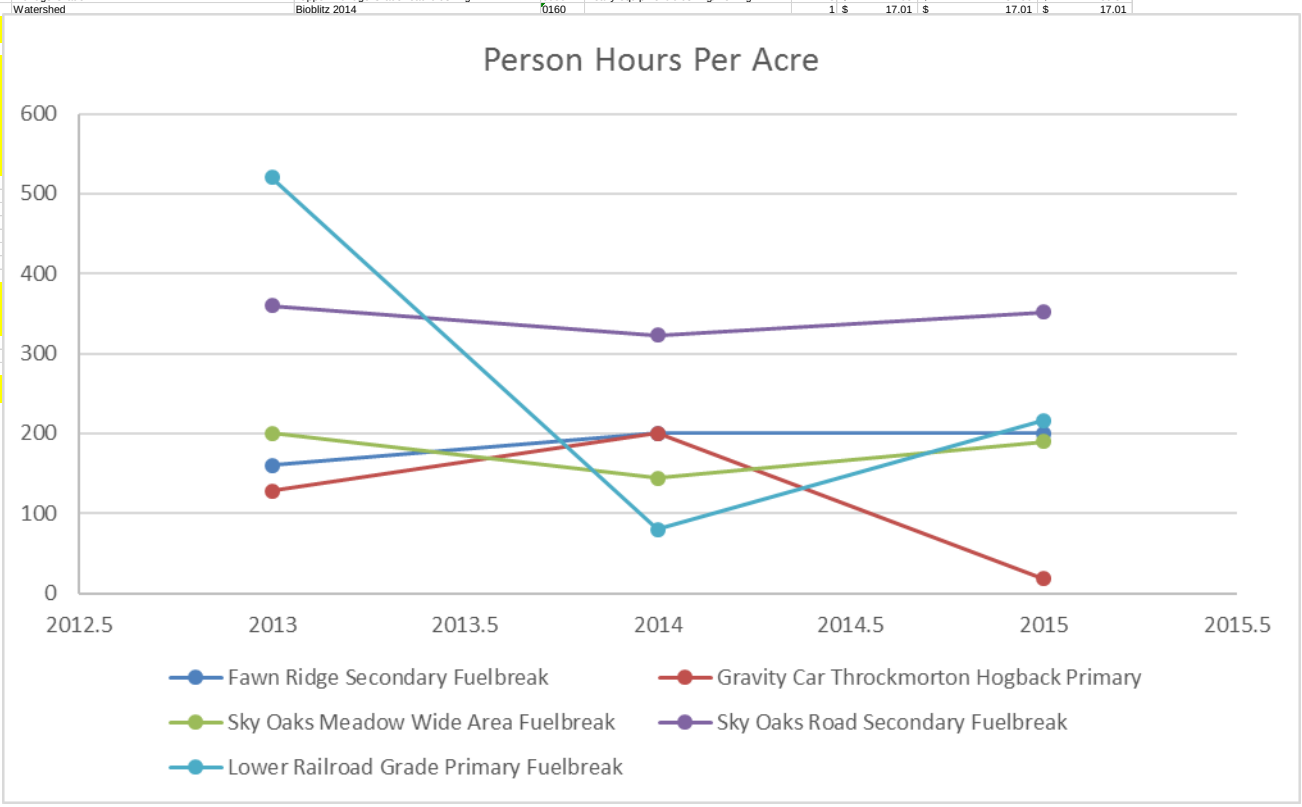
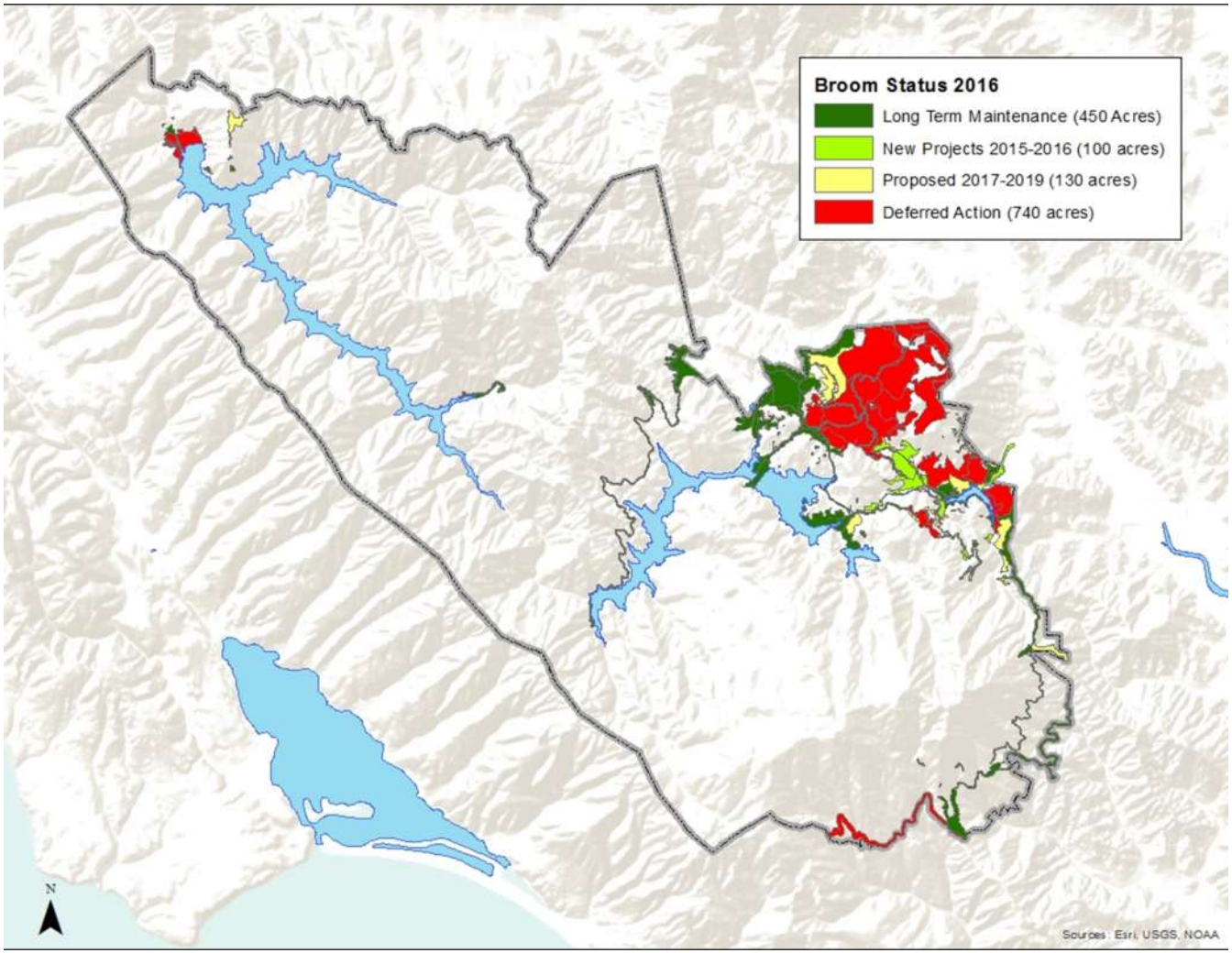


Formalizing our expectations

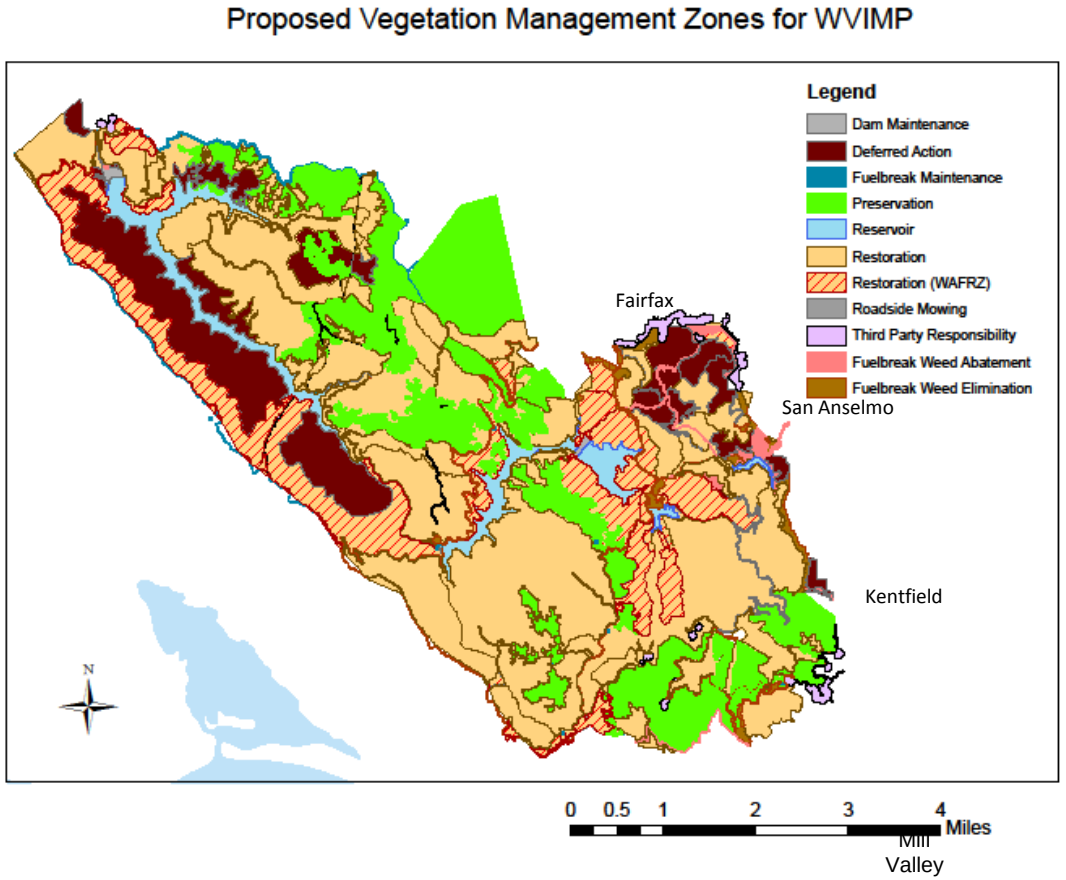
Coming Soon:

Official adoption of the "Deferred Action Zone"
740 acres of broom not managed over the first five years



The Deferred Action Zone: Not just for weeds

Areas with weeds or forest disease so severe or so remote that we will not get to it in the foreseeable future.



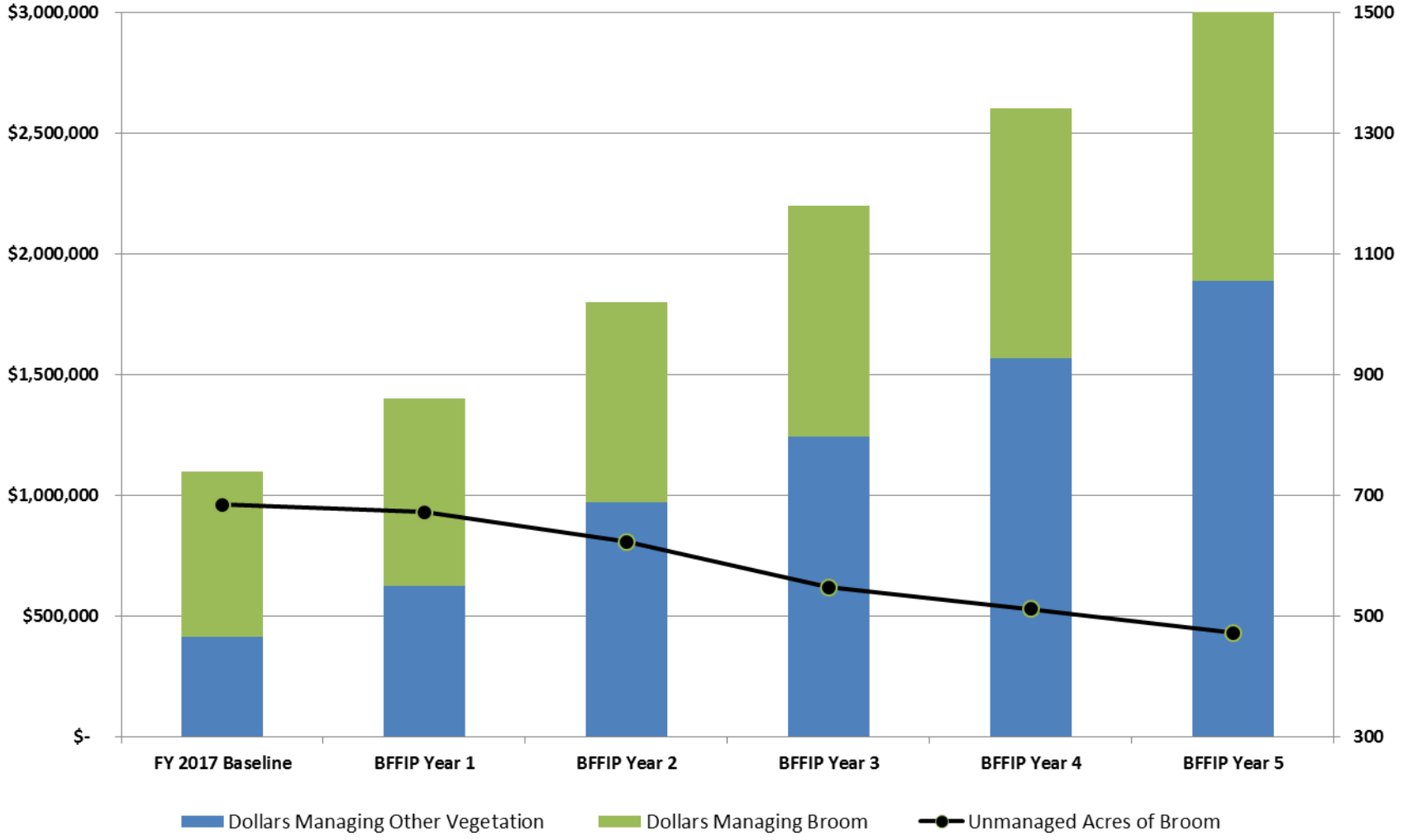
Keeping volunteerism in perspective

- Bald Hill Broom Bust was one of the largest and most productive broom event this year
- Productivity rate = 400 person-hours an acre
- Completed 0.05% of the 550 acres of broom management on Mt Tamalpais this fiscal yea

The greatest benefits from volunteer events come from community engagement, education, and good will.

Projected costs with Zero Use

BFFIP calls for annual increases of $400,000 for the next 5 years, until we reach an operating budget of $3,000,000 per year.



All of which is to say:

To successfully manage 1,400 acres of broom, and over 100 acres of other target weeds, on Mt Tamalpais with ZERO herbicides,
We are asking for an additional $400,000 a year for the next 5 years until our operational budget reaches $3 million annually.

Which translates into:

- 73,500 hours of field work per year
- 4,500 hours of supervision time per year
- 5,000 hours of ecosystem monitoring

- 28 Equivalent full time positions

Also needed:

- $1,000,000 in capital equipment (vehicles, computers, tools)
- Office space for at least 2 supervisors

District leadership has committed to scaling up to this level over a 5-year period.